

[946341]

Patent Application
of
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for

NETWORKED SYSTEM FOR INTERACTIVE COMMUNICATION AND
REMOTE MONITORING OF INDIVIDUALS

RELATED APPLICATION INFORMATION

This application is a continuation in part of application
Ser. No. 08/847,009 filed April 30, 1997. ^{now US PAT. # 5,897,493} This application
also claims priority from provisional application Ser. No.
60/041,746 filed March 28, 1997 and from provisional
application Ser. No. 60/041,751 filed March 28, 1997. All of
the above named applications are hereby incorporated by
reference.

FIELD OF THE INVENTION

The present invention relates generally to communication
systems for remote monitoring of individuals, and in
particular to a networked system for remotely monitoring
individuals and for communicating information to the
individuals through the use of script programs.

BACKGROUND OF THE INVENTION

In the United States alone, over 100 million people have
chronic health conditions, accounting for an estimated \$700
billion in annual medical costs. In an effort to control

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these medical costs, many healthcare providers have initiated outpatient or home healthcare programs for their patients.

The potential benefits of these programs are particularly great for chronically ill patients who must treat their

5 diseases on a daily basis. However, the success of these programs is dependent upon the ability of the healthcare providers to monitor the patients remotely to avert medical problems before they become complicated and costly.

Unfortunately, no convenient and cost effective monitoring
10 system exists for the patients who have the greatest need for monitoring, the poor and the elderly.

Prior attempts to monitor patients remotely have included the use of personal computers and modems to establish

15 communication between patients and healthcare providers.

However, computers are too expensive to give away and the patients who already own computers are only a small fraction of the total population. Further, the patients who own

computers are typically young, well educated, and have good
20 healthcare coverage. Thus, these patients do not have the greatest unmet medical needs. The patients who have the greatest unmet medical needs are the poor and elderly who do not own computers or who are unfamiliar with their use.

25 Similar attempts to establish communication between patients and healthcare providers have included the use of the Internet and internet terminals. Although internet terminals are somewhat less costly than personal computers, they are still too expensive to give away to patients. Moreover,
30 monthly on-line access charges are prohibitive for poor patients.

Other attempts to monitor patients remotely have included the use of medical monitoring devices with built-in modems.

35 Examples of such monitoring devices include blood glucose

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meters, respiratory flow meters, and heart rate monitors. Unfortunately, these monitoring devices are only designed to collect physiological data from the patients. They do not allow flexible and dynamic querying of the patients for other
5 information, such as quality of life measures or psychosocial variables of illness.

Prior attempts to monitor patients remotely have also included the use of interactive telephone or video response
10 systems. Such interactive systems are disclosed in U.S. Patents 5,390,238 issued to Kirk et al. on February 14, 1995, 5,434,611 issued to Tamura on July 18, 1995, and 5,441,047 issued to David et al. on August 15, 1995. One disadvantage
15 of these systems is that they either require a patient to call in to a central facility to be monitored or require the central facility to call the patient according to a rigid monitoring schedule.

If the patients are required to call the central facility,
20 only the compliant patients will actually call regularly to be monitored. Non-compliant patients will typically wait until an emergency situation develops before contacting their healthcare provider, thus defeating the purpose of the monitoring system. If the central facility calls each
25 patient according to a monitoring schedule, it is intrusive to the patient's life and resistance to the monitoring grows over time.

Another disadvantage of these conventional interactive
30 response systems is that they are prohibitively expensive for poor patients. Further, it is difficult to identify each patient uniquely using these systems. Moreover, these systems are generally incapable of collecting medical data from monitoring devices, such as blood glucose meters,
35 respiratory flow meters, or heart rate monitors.

OBJECTS AND ADVANTAGES OF THE INVENTION

In view of the above, it is an object of the present
5 invention to provide a simple and inexpensive system for
remotely monitoring patients and for communicating
information to the patients. It is another object of the
invention to provide a system which allows flexible and
dynamic querying of the patients. It is a further object of
10 the invention to provide a system which combines querying of
patients with medical device monitoring in the same
monitoring session. Another object of the invention is to
provide a monitoring system which incurs lower communications
charges than those incurred by conventional monitoring
15 systems. A further object of the invention is to provide a
monitoring system which may be used at any time convenient
for a patient.

These and other objects and advantages will become more
20 apparent after consideration of the ensuing description and
the accompanying drawings.

SUMMARY

25 The invention presents a networked system for remotely
monitoring an individual and for communicating information to
the individual. The system includes a server and a remote
interface for entering in the server a set of queries to be
answered by the individual. The server is preferably a world
30 wide web server and the remote interface is preferably a
personal computer or network terminal connected to the web
server via the Internet. The system also includes a remotely
programmable apparatus for interacting with the individual.
The apparatus is connected to the server via a communication
35 network, preferably the Internet. The apparatus interacts

with the individual in accordance with a script program received from the server.

The server includes a script generator for generating the
5 script program from the queries entered through the remote interface. The script program is executable by the apparatus to communicate the queries to the individual, to receive responses to the queries, and to transmit the responses from the apparatus to the server. The server also includes a
10 database connected to the script generator for storing the script program and the responses to the queries.

The apparatus has a communication device, such as a modem, for receiving the script program from the server and for
15 transmitting the responses to the server. The apparatus also has a user interface for communicating the queries to the individual and for receiving the responses to the queries. In the preferred embodiment, the user interface includes a display for displaying the queries and user input buttons for
20 entering the responses to the queries. In an alternative embodiment, the user interface includes a speech synthesizer for audibly communicating the queries and a speech recognizer for receiving spoken responses to the queries.

25 The apparatus also includes a memory for storing the script program and the responses to the queries. The apparatus further includes a microprocessor connected to the communication device, the user interface, and the memory. The microprocessor executes the script program to communicate
30 the queries to the individual, to receive the responses to the queries, and to transmit the responses to the server through the communication network.

In the preferred embodiment, the system also includes at
35 least one monitoring device for producing measurements of a

physiological condition of the individual and for transmitting the measurements to the apparatus. The apparatus further includes a device interface connected to the microprocessor for receiving the measurements from the monitoring device. The measurements are stored in the memory and transmitted to the server with the responses to the queries. The server also preferably includes a report generator connected to the database for generating a report of the measurements and responses. The report is displayed on the remote interface.

BRIEF DESCRIPTION OF THE DRAWINGS

- FIG. 1 is a block diagram of a networked system according to a preferred embodiment of the invention.
- FIG. 2 is a block diagram illustrating the interaction of the components of the system of FIG. 1.
- FIG. 3 is a perspective view of a remotely programmable apparatus of the system of FIG. 1.
- FIG. 4 is a block diagram illustrating the components of the apparatus of FIG. 3.
- FIG. 5 is a script entry screen according to the preferred embodiment of the invention.
- FIG. 6A is a listing of a sample script program according to the preferred embodiment of the invention.
- FIG. 6B is a continuation of the listing of FIG. 6A.
- FIG. 7 is a script assignment screen according to the preferred embodiment of the invention.
- FIG. 8 is a sample query appearing on a display of the apparatus of FIG. 3.
- FIG. 9 is a sample prompt appearing on the display of the apparatus of FIG. 3.
- FIG. 10 is a sample report displayed on a workstation of the system of FIG. 1.

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FIG. 11A is a flow chart illustrating the steps included in a monitoring application executed by the server of FIG. 1 according to the preferred embodiment of the invention.

5 FIG. 11B is a continuation of the flow chart of FIG. 11A.

FIG. 12A is a flow chart illustrating the steps included in the script program of FIGS. 6A - 6B.

FIG. 12B is a continuation of the flow chart of FIG. 12A.

10 FIG. 13 is a perspective view of a remotely programmable apparatus according to a second embodiment of the invention.

FIG. 14 is a sample prompt appearing on a display of the apparatus of FIG. 13.

15 FIG. 15 is a block diagram illustrating the components of the apparatus of FIG. 13.

FIG. 16 is a schematic block diagram illustrating the interaction of the server of FIG. 1 with the apparatus of FIG. 3 according to a third embodiment of the invention.

20 FIG. 17 is a first sample message appearing on the display of the apparatus of FIG. 3.

FIG. 18 is a second sample message appearing on the display of the apparatus of FIG. 3.

25 FIG. 19 is a script entry screen according to the third embodiment of the invention.

DETAILED DESCRIPTION

The invention presents a system and method for remotely
30 monitoring individuals and for communicating information to the individuals. In a preferred embodiment of the invention, the individuals are patients and the system is used to collect data relating to the health status of the patients.

However, it is to be understood that the invention is not

35 limited to remote ~~patient~~ monitoring ^{of patients}. The system and method

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of the invention may be used for any type of remote monitoring application. The invention may also be implemented as an automated messaging system for communicating information to individuals, as will be discussed in an alternative embodiment below.

A preferred embodiment of the invention is illustrated in FIGS. 1 - 12. Referring to FIG. 1, a networked system 16 includes a server 18 and a workstation 20 connected to server 18 through a communication network 24. Server 18 is preferably a world wide web server and communication network 24 is preferably the Internet. It will be apparent to one skilled in the art that server 18 may comprise a single stand-alone computer or multiple computers distributed throughout a network. Workstation 20 is preferably a personal computer, remote terminal, or web TV unit connected to server 18 via the Internet. Workstation 20 functions as a remote interface for entering in server 18 messages and queries to be communicated to the patients.

System 16 also includes first and second remotely programmable apparatuses 26 and 32 for monitoring first and second patients, respectively. Each apparatus is designed to interact with a patient in accordance with script programs received from server 18. Each apparatus is in communication with server 18 through communication network 24, preferably the Internet. Alternatively, each apparatus may be placed in communication with server 18 via wireless communication networks, cellular networks, telephone networks, or any other network which allows each apparatus to exchange data with server 18. For clarity of illustration, only two apparatuses are shown in FIG. 1. It is to be understood that system 16 may include any number of remotely programmable apparatuses for monitoring any number of patients.

In the preferred embodiment, each patient to be monitored is also provided with a monitoring device 28. Monitoring device 28 is designed to produce measurements of a physiological condition of the patient, record the measurements, and ^{remotely programmable} transmit the measurements to the patient's apparatus through a standard connection cable 30. Examples of suitable monitoring devices ²⁸ include blood glucose meters, respiratory flow meters, blood pressure cuffs, electronic weight scales, and pulse rate monitors. Such monitoring devices are well known in the art. The specific type of monitoring device ²⁸ provided to each patient is dependent upon the patient's disease. For example, diabetes patients are provided with a blood glucose meters for measuring blood glucose concentrations, asthma patients are provided with respiratory flow meters for measuring peak flow rates, obesity patients are provided with weight scales, etc.

FIG. 2 shows server 18, workstation 20, and apparatus 26 in greater detail. Server 18 includes a database 38 for storing script programs 40. ⁵ The script programs ⁴⁰ are executed by each apparatus ^{e.g., 26/32,} to communicate queries and messages to a patient, receive responses 42 to the queries, collect monitoring device measurements 44, and ⁴⁰ transmit responses 42 and measurements 44 to server 18. Database 38 is designed to store ~~the~~ responses 42 and measurements 44. Database 38 further includes a look-up table 46. Table 46 contains a list of the patients to be monitored, and for each patient, a unique patient identification code and a respective pointer to the script program assigned to the patient. Each remote ^{remotely programmable} apparatus ^{e.g., 26/32,} is designed to execute assigned script programs ⁴⁰ which it receives ^d from server 18.

FIGS. 3 - 4 show the structure of each ^{remotely programmable} apparatus, according to the preferred embodiment. For clarity, only ^{remotely programmable} apparatus 26 is shown since each ^{remotely programmable} apparatus of the preferred embodiment has

substantially identical structure to apparatus 26. Referring to FIG. 3, apparatus 26 includes a housing 62. Housing 62 is sufficiently compact to enable apparatus 26 to be hand-held and carried by a patient. Apparatus 26 also includes a display 64 for displaying queries and prompts to the patient. In the preferred embodiment, display 64 is a liquid crystal display (LCD).

Four user input buttons 70A, 70B, 70C, and 70D are located adjacent display 64. ^{User} ~~The~~ user input buttons ^{70A-D} are for entering in apparatus 26 responses ^{70A-D} to the queries and prompts. In the preferred embodiment, ~~the~~ user input buttons ^{70A-D} are momentary contact push buttons. In alternative embodiments, ~~the~~ user input buttons ^{70A-D} may be replaced by switches, keys, a touch sensitive display screen, or any other data input device.

Three monitoring device jacks 68A, 68B, and 68C are located on a surface of housing 62. ~~The~~ device jacks ^{68A-C} are for connecting apparatus 26 to a number of monitoring devices ²⁸ such as blood glucose meters, respiratory flow meters, or ³⁰ blood pressure cuffs, through respective connection cables ^{1A F.4.2} (not shown). Apparatus 26 also includes a modem jack 66 for connecting apparatus 26 to a telephone jack through a standard connection cord (not shown). Apparatus 26 further includes a visual indicator, such as a light emitting diode (LED) 74. LED 74 is for visually notifying the patient that he or she has unanswered queries stored in apparatus 26.

FIG. 4 is a schematic block diagram illustrating the components of apparatus 26 in greater detail. Apparatus 26 includes a microprocessor 76 and a memory 80 connected to microprocessor 76. Memory 80 is preferably a non-volatile memory, such as a serial EEPROM. Memory 80 stores script ⁴⁰ programs ¹⁸ received from ~~the~~ server, ⁴⁴ measurements ⁴² received from monitoring device 28, responses ⁴² to queries, and the patient's

unique identification code. Microprocessor 76 also includes built-in read only memory (ROM) which stores firmware for controlling the operation of apparatus 26. The firmware includes a script interpreter used by microprocessor 76 to execute the script programs. The script interpreter interprets script commands which are executed by microprocessor 76. Specific techniques for interpreting and executing script commands in this manner are well known in the art.

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Microprocessor 76 is preferably connected to memory 80 using a standard two-wire I²C interface. Microprocessor 76 is also connected to user input buttons 70, LED 74, a clock 84, and a display driver 82. Clock 84 indicates the current date and time to microprocessor 76. For clarity of illustration, clock 84 is shown as a separate component, but is preferably built into microprocessor 76. Display driver 82 operates under the control of microprocessor 76 to display information on display 64. Microprocessor 76 is preferably a PIC 16C65 processor which includes a universal asynchronous receiver transmitter (UART) 78. UART 78 is for communicating with a modem 86 and a device interface 90. A CMOS switch 88 under the control of microprocessor 76 alternately connects modem 86 and interface 90 to UART 78.

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Modem 86 is connected to a telephone jack 22 through modem jack 66. Modem 86 is for exchanging data with server 18 through communication network 24. The data includes script programs which are received from the server as well as responses to queries, device measurements, script identification codes, and the patient's unique identification code which modem 86 transmits to the server. Modem 86 is preferably a complete 28.8 K modem commercially available from Cermetek, although any suitable modem may be used.

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Device interface 90 is connected to device jacks 68A, 68B, and 68C. Device interface 90 is for interfacing with a number of monitoring devices²⁸ such as blood glucose meters, respiratory flow meters, blood pressure cuffs, weight scales, or pulse rate monitors, through the device jacks^{68A-C}. Device interface 90 operates under the control of microprocessor 76 to collect measurements⁴⁴ from the monitoring devices²⁸ and to output the measurements to microprocessor 76 for storage in memory 80. In the preferred embodiment, interface 90 is a standard RS232 interface. For simplicity of illustration, only one device interface⁹⁰ is shown in FIG. 4. However, in alternative embodiments, apparatus 26 may include multiple device interfaces to accommodate monitoring devices which have different connection standards.

Referring again to FIG. 2, server 18 includes a monitoring application 48. Monitoring application 48 is a controlling software application executed by server 18 to perform the various functions described below. Application 48 includes a script generator 50, a script assignor 52, and a report generator 54. Script generator 50 is designed to generate script programs 40 from script information entered through workstation 20. The script information is entered through a script entry screen 56. In the preferred embodiment, script entry screen 56 is implemented as a web page on server 18. Workstation 20 includes a web browser for accessing the web page to enter the script information.

FIG. 5 illustrates script entry screen 56 as it appears on workstation 20. Screen 56 includes a script name field 92 for specifying the name of a script program to be generated. Screen 56 also includes entry fields 94 for entering a set of queries to be answered by a patient. Each entry field 94 has corresponding response choice fields 96 for entering response choices for the query. Screen 56 further includes check

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~~at~~ boxes 98 for selecting a desired monitoring device from which to collect measurements, such as a blood glucose meter, respiratory flow meter, or blood pressure cuff.

5 Screen 56 additionally includes a connection time field 100 for specifying a prescribed connection time at which each apparatus²⁶ executing the script is to establish a subsequent communication link to the server¹⁸. The connection time is preferably selected to be the time at which communication rates are the lowest, such as 3:00 AM. Screen 56 also includes a CREATE SCRIPT button 102 for instructing the script generator⁵⁰ to generate a script program⁴⁰ from the information entered in screen 56. Screen 56 further includes a CANCEL button 104 for canceling the information entered in screen 56.

a In the preferred embodiment, each script program⁴⁰ created by the script generator⁵⁰ conforms to the standard file format used on UNIX systems. In the standard file format, each command is listed in the upper case and followed by a colon. Every line in the script program⁴⁰ is terminated by a linefeed character {LF}, and only one command is placed on each line. The last character in the script program⁴⁰ is a UNIX end of file character {EOF}. Table 1 shows an exemplary listing of script commands used in the preferred embodiment of the invention.

TABLE 1 - SCRIPT COMMANDS

Command	Description
CLS: {LF}	Clear the display.
ZAP: {LF}	Erase from memory the last set of query responses recorded.
LED: b{LF}	Turn the LED on or off, where b is a binary digit of 0 or 1. An argument of 1 turns on the LED, and an argument of 0 turns off the LED.

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DISPLAY: {chars}{LF}	Display the text following the DISPLAY command.
INPUT: mmmm{LF}	Record a button press. The m's represent a button mask pattern for each of the four input buttons. Each m contains an "X" for disallowed buttons or an "O" for allowed buttons. For example, INPUT: OXOX{LF} allows the user to press either button #1 or #3.
WAIT: {LF}	Wait for any one button to be pressed, then continue executing the script program.
COLLECT: device{LF}	Collect measurements from the monitoring device specified in the COLLECT command. The user is preferably prompted to connect the specified monitoring device to the apparatus and press a button to continue.
NUMBER: aaaa{LF}	Assign a script identification code to the script program. The script identification code from the most recently executed NUMBER statement is subsequently transmitted to the server along with the query responses and device measurements. The script identification code identifies to the server which script program was most recently executed by the remote apparatus.
DELAY: t {LF}	Wait until time t specified in the DELAY command, usually the prescribed connection time.
CONNECT: {LF}	Perform a connection routine to establish a communication link to the server, transmit the patient identification code, query responses, device measurements, and script identification code to the server, and receive and store a new script program. When the server instructs the apparatus to disconnect, the script interpreter is restarted, allowing the new script program to execute.

The script commands illustrated in Table 1 are representative of the preferred embodiment and are not intended to limit the scope of the invention. After consideration of the ensuing description, it will be apparent to one skilled in the art many other suitable scripting languages and sets of script commands may be used to implement the invention.

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Script generator **50** preferably stores a script program
template which it uses to create each script program.⁴⁰ To
generate a script program,⁴⁰ script generator **50** inserts into
the template the script information entered in screen **56**.
5 **A** For example, FIGS. 6A - 6B illustrate a sample script program⁴⁰
created by script generator **50** from the script information
shown in FIG. 5.

A The script program⁴⁰ includes display commands to display the
10 queries and response choices entered in fields **94** and **96**,
A respectively. The script program⁴⁰ also includes input
A commands⁴² to receive responses⁴² to the queries. The script
A program⁴⁰ further includes a collect command to collect device
A measurements⁴⁴ from the monitoring device²⁸ specified in check
15 **A** boxes **98**. The script program⁴⁰ also includes commands to
A establish a subsequent communication link to the server¹⁸ at
A the connection time specified in field **100**.^{Fig. 5} The steps
A included in the script program⁴⁰ are also shown in the flow
chart of FIGS. 12A - 12B and will be discussed in the
20 operation section below.

Referring again to FIG. 2, script assignor **52** is for
assigning script programs **40** to the patients. Script
programs **40** are assigned in accordance with script assignment
25 information entered through workstation **20**. The script
assignment information is entered through a script assignment
screen **57**, which is preferably implemented as a web page on
server **18**.

30 FIG. 7 illustrates a sample script assignment screen **57** as it
appears on workstation **20**. Screen **57** includes check boxes
A **106** for selecting a script program⁴⁰ to be assigned, and check
boxes **108** for selecting the patients to whom the script
program is to be assigned. Screen **57** also includes an ASSIGN
35 SCRIPT button **112** for entering the assignments. When button

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Q 112 is pressed, ~~the~~ script assignor⁵² creates and stores for each patient selected in check boxes 108 a respective pointer
a to the script program⁴⁰ selected in check boxes 106. Each
a pointer is stored in the patient look-up table⁴⁶ of the
5 a database²⁸. Screen 57 further includes an ADD SCRIPT button
110 for accessing the script entry screen and a DELETE SCRIPT
a button 114 for deleting a script program⁴⁰.

Referring again to FIG. 2, report generator 54 is designed to
10 a generate a patient report 58 from ~~the~~ responses⁴² and device
a measurements⁴⁴ received in server 18. Patient report 58 is
displayed on workstation 20. FIG. 10 shows a sample patient
report 58 produced by report generator 54 for a selected
patient. Patient report 58 includes a graph 116 of the
15 a device measurements⁴⁴ received from the patient, as well as a
listing of responses 42 received from the patient. Specific
techniques for writing a report generator program to display
data in this manner are well known in the art.

20 The operation of the preferred embodiment is illustrated in
FIGS. 1 - 12. FIG. 11A is a flow chart illustrating steps
included in the monitoring application executed by server 18.
FIG. 11B is a continuation of the flow chart of FIG. 11A. In
step 202, server 18 determines if new script information has
25 been entered through script entry screen 56. If new script
information has not been entered, server 18 proceeds to step
206. If new script information has been entered, server 18
proceeds to step 204.

30 As shown in FIG. 5, the script information includes a set of
a queries, and for each of the queries, corresponding responses⁴⁴
choices. The script information also includes a selected
monitoring device type from which to collect device
a measurements⁴⁴. The script information further includes a
35 prescribed connection time for each apparatus to establish a

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a subsequent communication link to ~~the~~ server¹⁸. The script information is generally entered in server 18 by a healthcare provider, such as the patients' physician or case manager. Of course, any person desiring to communicate with the patients may also be granted access to server 18 to create and assign script programs⁴⁰. Further, it is to be understood that ~~the~~ system¹⁶ may include any number of remote interfaces for entering script generation and script assignment information in server 18.

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In step 204, script generator 50 generates a script program from the information entered in screen 56. The script program is stored in database 38. Steps 202 and 204 are preferably repeated to generate multiple script programs, e.g. a script program for diabetes patients, a script program for asthma patients, etc. Each script program corresponds to a respective one of the sets of queries entered through script entry screen 56. Following step 204, server 18 proceeds to step 206.

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In step 206, server 18 determines if new script assignment information has been entered through assignment screen 57. If new script assignment information has not been entered, server 18 proceeds to step 210. If new script assignment information has been entered, server 18 proceeds to step 208. As shown in FIG. 7, the script programs are assigned to each patient by selecting a script program through check boxes 106, selecting the patients to whom the selected script program is to be assigned through check boxes 108, and pressing the ASSIGN SCRIPT button 112. When button 112 is pressed, script assignor 52 creates for each patient selected in check boxes 108 a respective pointer to the script program selected in check boxes 106. In step 208, each pointer is stored in look-up table 46 of database 38. Following step 208, server 18 proceeds to step 210.

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In step 210, server 18 determines if any of the apparatuses
 a are remotely connected to the server. Each patient to be
 monitored is preferably provided with his or her own ^{remotely programmable}
 5 apparatus which has the patient's unique identification code
 stored therein. Each patient is thus uniquely associated
 with a respective one of the apparatuses. If none of the
 apparatuses is connected, server 18 proceeds to step 220.

10 If an apparatus is connected, server 18 receives from the
 apparatus the patient's unique identification code in step
 212. In step 214, server 18 receives from the apparatus the
 query responses 42, device measurements 44, and script
 identification code recorded during execution of a previously
 15 assigned script program. ¹⁸The script identification code
 a identifies to ~~the~~ server ¹⁸ which script program was executed by
 a the apparatus to record the query responses ⁴² and device
 a measurements ⁴⁴. The responses, device measurements, and script
 identification code are stored in database 38.

20 In step 216, server 18 uses the patient identification code
 to retrieve from table 46 the pointer to the script program
 assigned to the patient. ~~The~~ server ¹⁸ then retrieves the
 assigned script program from database 38. In step 218,
 25 server 18 transmits the assigned script program to the
 a patient's ^{remotely programmable} apparatus through communication network 24.
 Following step 218, server 18 proceeds to step 220.

In step 220, server 18 determines if a patient report request
 30 has been received from workstation 20. If no report request
 has been received, server 18 returns to step 202. If a
 report request has been received for a selected patient,
 a server 18 retrieves from database 38 the measurements ⁴⁴ and
 a query responses ⁴² last received from the patient, step 222. In
 35 step 224, server 18 generates and displays patient report 58

on workstation 20. As shown in FIG. 10, report 58 includes
a the device measurements⁴⁴ and query responses⁴² last received¹⁸
a from the patient. Following step 224, the server¹⁸ returns to
step 202.

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FIGS. 12A - 12B illustrate the steps included in the script
program executed by apparatus 26. Before the script program
is received, apparatus 26 is initially programmed with the
patient's unique identification code and the script
10 interpreter used by microprocessor 76 to execute the script
program. The initial programming may be achieved during
manufacture or during an initial connection to server 18.
Following initial programming, apparatus 26 receives from
server 18 the script program assigned to the patient
15 associated with apparatus 26. The script program is received
by modem 86 through a first communication link and stored in
memory 80.

In step 302, microprocessor 76 assigns a script
20 identification code to the script program and stores the
script identification code in memory 80. The script
a identification code is subsequently transmitted to the server¹⁸
a along with the query responses⁴² and device measurements⁴⁴ to
a identify to the server¹⁸ which script program was most recently
25 a executed by the apparatus²⁶. In step 304, microprocessor 76
lights LED 74 to notify the patient that he or she has
unanswered queries stored in apparatus 26. LED 74 preferably
remains lit until the queries are answered by the patient.
In step 306, microprocessor 76 erases from memory 80 the
30 last set of query responses recorded.

In step 308, microprocessor 76 prompts the patient by
displaying on display 64 "ANSWER QUERIES NOW? PRESS ANY
BUTTON TO START". In step 310, microprocessor 76 waits until
35 a reply to the prompt is received from the patient. When a

reply is received, microprocessor 76 proceeds to step 312.
In step 312, microprocessor 76 executes successive display
and input commands to display the queries and response
choices on display 64 and to receive responses to the
5 queries.

FIG. 8 illustrates a sample query and its corresponding
response choices as they appear on display 64. The response
choices are positioned on display 64 such that each response
10 choice is located proximate a respective one of the input
buttons. In the preferred embodiment, each response choice
is displayed immediately above a respective input button.
The patient presses the button corresponding to his or her
response. Microprocessor 76 stores each response in memory
15 80.

In steps 314 - 318, microprocessor 76 executes commands to
collect device measurements from a selected monitoring
device. The script program specifies the selected monitoring
20 device from which to collect the measurements. In step 314,
microprocessor 76 prompts the patient to connect the selected
monitoring device for example a blood glucose meter, to one
of the device jacks. A sample prompt is shown in FIG. 9. In
step 316, microprocessor 76 waits until a reply to the prompt
25 is received from the patient. When a reply is received,
microprocessor 76 proceeds to step 318. Microprocessor 76
also connects UART 78 to interface 90 through switch 88. In
step 318, microprocessor 76 collects the device measurements
from monitoring device 28 through interface 90. The
30 measurements are stored in memory 80.

In step 320, microprocessor 76 prompts the patient to connect
apparatus 26 to telephone jack 22 so that apparatus 26 may
connect to server 18 at the prescribed connection time. In
35 step 322, microprocessor 76 waits until a reply to the prompt

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is received from the patient. When a reply is received, microprocessor 76 turns off LED 74 in step 324. In step 326, microprocessor 76 waits until it is time to connect to server 18. Microprocessor 76 compares the connection time
5 specified in the script program to the current time output by clock 84. When it is time to connect, microprocessor 76 connects UART 78 to modem 86 through switch 88.

In step 328, microprocessor 76 establishes a subsequent
10 communication link between apparatus 26 and server 18 through modem 86 and communication network 24. If the connection fails for any reason, microprocessor 76 repeats step 328 to get a successful connection. In step 330, microprocessor 76
a transmits the device measurements⁴⁴, query responses⁴², script
15 identification code, and patient identification code stored in memory 80 to server 18 through the subsequent communication link. In step 332, microprocessor 76 receives through modem 86 a new script program from server 18. The new script program is stored in memory 80 for subsequent
20 execution by microprocessor 76. Following step 332, the script program ends.

One advantage of the monitoring system of the present invention is that it allows each patient to select a
25 convenient time to respond to the queries, so that the monitoring system is not intrusive to the patient's schedule. A second advantage of the monitoring system is that it incurs very low communications charges because each remote apparatus
a connects to the server¹⁸ at times when communication rates are
30 lowest. Moreover, the cost to manufacture each remote
a apparatus²⁶ is very low compared to personal computers or internet terminals, so that the monitoring system is highly affordable.

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A third advantage of the monitoring system is that it allows
 a each apparatus²⁶ to be programmed remotely through script
 a programs⁴⁰. Patient surveys, connection times, display
 prompts, selected monitoring devices, patient customization,
 5 a and other operational details of each apparatus²⁶ may be easily
 a changed by transmitting a new script program⁴⁰ to the
 a apparatus²⁶. Moreover, each script program⁴⁰ may be easily
 a created and assigned by remotely accessing the server¹⁸ through
 the Internet. Thus, the invention provides a powerful,
 10 convenient, and inexpensive system for remotely monitoring a
 large number of patients.

FIGS. 13 - 15 illustrate a second embodiment of the invention
 in which each remotely programmable apparatus has speech
 15 recognition and speech synthesis functionality. FIG. 13
 a shows a perspective view of an ^{remotely programmable} apparatus²⁷ according to the
 second embodiment. Apparatus 27 includes a speaker 72 for
 audibly communicating queries and prompts to the patient.
 Apparatus 27 also includes a microphone 118 for receiving
 20 spoken responses to the queries and prompts. Apparatus 27
 may optionally include a display 64 for displaying prompts to
 the patient, as shown in FIG. 14.

FIG. 15 is a schematic block diagram illustrating the
 25 components of apparatus 27 in greater detail. Apparatus 27
 a is similar in design to the apparatus²⁶ of the preferred
 embodiment except that apparatus 27 includes an audio
 processor chip 120 in place of microprocessor 76. Audio
 processor chip 120 is preferably an RSC-164 chip commercially
 30 available from Sensory Circuits Inc. of 1735 N. First Street,
 San Jose, California 95112.

Audio processor chip 120 has a microcontroller 122 for
 a executing script programs received from the server¹⁸. A memory
 35 80 is connected to microcontroller 122. Memory 80 stores

the script programs and a script interpreter used by
microcontroller **122** to execute the script programs. Memory
80 also stores measurements received from monitoring device
28, responses to the queries, script identification codes,
5 and the patient's unique identification code.

Audio processor chip **120** also has built in speech synthesis
functionality for synthesizing queries and prompts to a
patient through speaker **72**. For speech synthesis, chip **120**
10 includes a digital to analog converter (DAC) **142** and an
amplifier **144**. DAC **142** and amplifier **144** drive speaker **72**
under the control of microcontroller **122**.

Audio processor chip **120** further has built in speech
15 recognition functionality for recognizing responses spoken
into microphone **118**. Audio signals received through
microphone **118** are converted to electrical signals and sent
to a preamp and gain control circuit **128**. Preamp and gain
control circuit **128** is controlled by an automatic gain
20 control circuit **136**, which is in turn controlled by
microcontroller **122**. After being amplified by preamp **128**,
the electrical signals enter chip **120** and pass through a
multiplexer **130** and an analog to digital converter (ADC)
132. The resulting digital signals pass through a digital
25 logic circuit **134** and enter microcontroller **122** for speech
recognition.

Audio processor chip **120** also includes a RAM **138** for short
term memory storage and a ROM **140** which stores programs
30 executed by microcontroller **122** to perform speech recognition
and speech synthesis. Chip **120** operates at a clock speed
determined by a crystal **126**. Chip **120** also includes a clock
84 which provides the current date and time to
microcontroller **122**. As in the preferred embodiment,
35 apparatus **27** includes an LED **74**, display driver **82**, modem

86, and device interface 90, all of which are connected to microcontroller 122.

The operation of the second embodiment is similar to the operation of the preferred embodiment except that queries, response choices, and prompts are audibly communicated to the patient through speaker 72 rather than being displayed to the patient on display 64. The operation of the second

embodiment also differs from the operation of the preferred embodiment in that responses to the queries and prompts are received through microphone 118 rather than through user input buttons.

The script programs of the second embodiment are similar to the script program shown in FIGS. 6A - 6B, except that each display command is replaced by a speech synthesis command and each input command is replaced by a speech recognition command. The speech synthesis commands are executed by microcontroller 122 to synthesize the queries, response choices, and prompts through speaker 72. The speech recognition commands are executed by microcontroller 122 to recognize responses spoken into microphone 118.

For example, to ask the patient how he or she feels and record a response, microcontroller 122 first executes a speech synthesis command to synthesize through speaker 72 "How do you feel? Please answer with one of the following responses: very bad, bad, good, or very good." Next, microcontroller 118 executes a speech recognition command to recognize the response spoken into microphone 118. The recognized response is stored in memory 80 and subsequently transmitted to the server. Other than the differences described, the operation and advantages of the second embodiment are the same as the operation and advantages of the preferred embodiment described above.

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Although the first and second embodiments focus on querying individuals and collecting responses to the queries, the system of the invention is not limited to querying applications. The system may also be used simply to communicate messages to the individuals. FIGS. 16 - 19 illustrate a third embodiment in which the system is used to perform this automated messaging function. In the third embodiment, each script program contains a set of statements to be communicated to an individual rather than a set of queries to be answered by the individual. Of course, it will be apparent to one skilled in the art that the script programs may optionally include both queries and statements.

The third embodiment also shows how the queries and statements may be customized to each individual by merging personal data with the script programs, much like a standard mail merge application. Referring to FIG. 16, personal data relating to each individual is preferably stored in look-up table 46 of database 38. By way of example, the data may include each individual's name, the name of each individual's physician, test results, appointment dates, or any other desired data. As in the preferred embodiment, database 38 also stores generic script programs 40 created by script generator 50.

Server 18 includes a data merge program 55 for merging the data stored in table 46 with generic script programs 40. Data merge program 55 is designed to retrieve selected data from table 46 and to insert the data into statements in generic script programs 40, thus creating custom script programs 41. Each custom script program 41 contains statements which are customized to an individual. For example, the statements may be customized with the

individual's name, test results, etc. Examples of such customized statements are shown in FIGS. 17 - 18.

The operation of the third embodiment is similar to the operation of the preferred embodiment except that the script programs are used to communicate messages to the individuals rather than to query the individuals. Each message is preferably a set of statements. Referring to FIG. 19, the statements may be entered in ~~the~~ ¹⁸ server ¹ through script entry screen 56, just like the queries of the preferred embodiment.

Each statement preferably includes one or more insert commands specifying data from table 46 to be inserted into the statement. The insert commands instruct data merge program 55 to retrieve the specified data from database 38 and to insert the data into the statement. For example, the insert commands shown in FIG. 19 instruct ~~the~~ data merge program ⁵⁵ to insert a physician name, an appointment date, a patient name, and a test result into the statements. As in the preferred embodiment, each statement may also include one or more response choices which are entered in fields 96.

Following entry of the statements and response choices, CREATE SCRIPT button 102 is pressed. When button 102 is pressed, script generator 50 generates a generic script program from the information entered in screen 56. The generic script program is similar to the script program shown in FIGS. 6A - 6B, except that the display commands specify statements to be displayed rather than queries. Further, the statements include insert commands specifying data to be inserted into the script program. As in the preferred embodiment, multiple script programs are preferably generated, e.g. a generic script program for diabetes patients, a generic script program for asthma patients, etc. The generic script programs are stored in database 38.

Following generation of the generic script programs, server 18 receives script assignment information entered through script assignment screen 57. As shown in FIG. 7, the script programs are assigned by first selecting one of the generic script programs through check boxes 106, selecting individuals through check boxes 108, and pressing the ASSIGN SCRIPT button 112. When button 112 is pressed, data merge
 a program 55 creates a custom script program⁴¹ for each
 10 individual selected in check boxes 108.

a Each custom script program⁴¹ is preferably created by using the selected generic script program as a template. For each individual selected, data merge program 55 retrieves from
 15 database 38 the data specified in the insert commands. Next, data merge program 55 inserts the data into the appropriate
 a statements in the generic script program⁴⁰ to create a custom
 a script program⁴¹ for the individual. Each custom script
 a program⁴¹ is stored in database 38.

20 a As each custom script program⁴¹ is generated for an individual, a script assignor 52 assigns the script program⁴¹ to the individual. This is preferably accomplished by creating a pointer to the custom script program and storing the pointer
 25 with the individual's unique identification code in table 46.

inventor
 a When the individual's remote²⁶ ^{programmable} apparatus²⁶ connects to server 18, server 18 receives from the apparatus²⁶ the individual's unique identification code. Server 18 uses the unique identification code to retrieve from table 46 the pointer to
 30 the custom script program assigned to the individual. Next, server 18 retrieves the assigned script program from database
 a 38 and transmits the script program to the individual's²⁶ ^{remotely programmable}
 a apparatus²⁶ through communication network 24.

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The apparatus receives and executes the script program. The execution of the script program is similar to the execution described in the preferred embodiment, except that statements are displayed to the individual rather than queries. FIGS.

17 - 18 illustrate two sample statements as they appear on display 64. Each statement includes a response choice, preferably an acknowledgment such as "OK". After reading a statement, the individual presses the button ^{70 AND} corresponding to the response choice to proceed to the next statement.

Alternatively, the script program may specify a period of time that each statement is to be displayed before proceeding to the next statement. The remaining operation of the third embodiment is analogous to the operation of the preferred embodiment described above.

Although it is presently preferred to generate a custom script program ⁴¹ for each individual as soon as script assignment information is received for the individual, it is also possible to wait until the individual's apparatus ²⁶ connects to ¹⁸ the server ¹⁸ before generating the custom script program ⁴¹. This is accomplished by creating and storing a pointer to the generic script program ⁴⁰ assigned to the individual, as previously described in the preferred embodiment. When the individual's apparatus ²⁶ connects to the server ¹⁸, data merge program 55 creates a custom script program ⁴¹ for the individual from the generic script program ⁴⁰ assigned to the individual. The custom script program ⁴¹ is then sent to the individual's apparatus ²⁶ for execution.

SUMMARY, RAMIFICATIONS, AND SCOPE

Although the above description contains many specificities, these should not be construed as limitations on the scope of the invention but merely as illustrations of some of the presently preferred embodiments. Many other embodiments of

the invention are possible. For example, the scripting language and script commands shown are representative of the preferred embodiment. It will be apparent to one skilled in the art many other scripting languages and specific script commands may be used to implement the invention.

Moreover, the invention is not limited to the specific applications described. The system and method of the invention have many other application both inside and outside the healthcare industry. For example, pharmaceutical manufacturers may apply the system in the clinical development and post marketing surveillance of new drugs, using the system as an interactive, on-line monitoring tool for collecting data on the efficacy, side effects, and quality of life impact of the drugs. Compared to the current use of labor intensive patient interviews, the system provides a fast, flexible, and cost effective alternative for monitoring the use and effects of the drugs.

The system may also be used by home healthcare companies to enhance the service levels provided to customers, e.g. panic systems, sleep surveillance, specific monitoring of disease conditions, etc. Alternatively, the system may be used to monitor and optimize the inventory of home stationed health supplies. As an example, the system may be connected to an appropriate measuring device to optimize timing of oxygen tank delivery to patients with ^{as} COPD.

The system and method of the invention also have many applications outside the healthcare industry. For example, the system may be used for remote education over the Internet, facilitating educational communication with children or adult trainees who lack access to sophisticated and expensive computer equipment. The system may also be

used by law enforcement officers to perform on-line surveillance of individuals on probation or parole.

Further, the invention has numerous applications for
5 gathering data from remotely located devices. For example,
the system may be used to collect data from smart appliances,
such as identification check systems. Alternatively, the
system may be applied to the remote monitoring of facilities,
including safety and security monitoring, or to environmental
10 monitoring, including pollution control and pipeline
monitoring. Many other suitable applications of the
invention will be apparent to one skilled in the art.

Therefore, the scope of the invention should be determined
15 not by the examples given, but by the appended claims and
their legal equivalents.

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